THE BIONOMICS OF *TABANUS APREPES*, AND OTHER AUSTRALIAN TABANIDAE.

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(Plates I and II.)

During recent years the number of described species of Australian Tabanidae, or March-flies, as they are almost universally called in this country, has been increased very considerably, and with this increase there has come a wider knowledge of the distribution of the various genera and species. While advancement has taken place in this direction, little progress appears to have been made towards acquiring an accurate knowledge of the life-history and habits of any of these flies, and, up to the present time, no precise information has been published concerning oviposition, larval development, feeding habits and pupation of any of our numerous species.

In this paper I propose to describe in some detail the life-history, habits and developmental stages of *Tabanus aprepes*, Taylor, and *T. rufinotatus*, Bigot, which have been reared from egg to adult, and to discuss other species so far as present knowledge permits.

Tabanus aprepes, Tayl.

T. aprepes, Taylor, Proc. Linn. Soc. N.S.W. xliv, p. 56.

T. batchelori, Taylor, *loc. cit.* p. 58.

Distribution. This species is recorded from South Queensland (Eidsvold), North Queensland (Townsville and Kuranda), and the Northern Territory (Darwin and Batchelor).

Breeding-places. The following notes are based on observations made during the period 18th October 1919 to September 1920, in three localities within the municipal boundaries of Townsville, namely, (1) a small permanent rock-hole and stream arising from it, situated within half a mile of the Institute building, (2) a small shallow swamp about 250 yards distant from the rock-hole, and (3) a group of similar swamps on the outskirts of the town.

During the wet season and for some months afterwards the rock-hole and adjoining pools and riffles (Plates I and II, fig. i.) are completely swept by a rapid torrent of surface and soakage water from adjacent land; but later, when the flow is reduced to a regular and steady trickle, there is present a plentiful supply of algal growth and three or four feet of clear water in the rock-hole and rather less in the pools. From June to December 1919 the moist banks were searched unsuccessfully for larvae and pupae resulting from eggs deposited during the previous summer. On 10th October 1919 and later, Tabanidae were occasionally seen flying about, or momentarily resting upon the heads of children playing on the sea beach distant about 300 yards from the rock-hole—then the only locality within a mile or more from which they could have emerged. The species could not be determined with certainty, but was provisionally referred to *T. aprepes*.

More frequent visits were now paid to the locality in the hope of definitely associating with it the flies occasionally noticed in the vicinity. Digging operations were undertaken wherever the soil was sufficiently moist or loose enough to permit of the emergence of the flies from the ground; then the harder and drier parts of the bank and neighbouring soil were dug over and sifted, the rocks and herbage overhanging the water were searched frequently for ovipositing females or their eggs, and a few

horses and cows which drank at the lower pools were watched, but no evidence of TABANIDAE could be found until 6th January, or two days after the first heavy fall of rain (106 points) since the preceding March.

On 6th January a female *T. aprepes* was observed on a twig about four and a half feet over the water (Plate I), apparently about to oviposit, when she was disturbed by a spider and flew off.

On 13th January three egg-masses were found on the same twig, all of which appeared to have hatched, but on removal to the laboratory three living larvae were rescued from a spider's web which enveloped one end of one mass. Although there appeared to be no unhatched eggs in the masses, the latter were placed over water, and during the night 110 larvae were produced, some of which were subsequently reared to the fly stage and identified as *T. aprepes*.

From 16th January until 16th April numerous larvae of *T. aprepes* were found in the algae floating on the surface of the water. Heavy floods swept the holes in the locality during the month of April, after which larvae were not found.

On 2nd April a female *T. aprepes* was observed to alight on the twig from which eggs were taken on the 13th January, and the process of oviposition was observed, with the aid of a magnifying glass, from commencement to conclusion, when the fly was captured and the eggs removed to the laboratory, where larvae were subsequently reared.

Of the 39 egg-masses collected here (Locality 1) between 13th January and 9th April, five were found on twigs and six on grass leaves or seed-heads overhanging water in the rock-hole (Plate I), the majority being from 3 to 4½ feet above the surface; three were found on grass leaves a few inches above the water trickling from the rock-hole, and 25 on the terminal shoots of couch-grass overhanging a sloping bank (Plate II), the surface of which was oozing with soakage water and algal growth.

The adjacent swamp (Locality 2) dried early in July 1919, and remained in this condition until 4th January 1920. Towards the end of April 1920 the surface area reached its maximum, there being then about 4½ feet of water in the deepest parts. Repeated searches were made for egg-masses on plants overhanging the margin and on lily and other leaves floating on the surface, but none were found. During these searches numerous half-grown to full-grown larvae (*T. aprepes*) were found clinging to the lower surface of the lily leaves, or to the stems, or hidden in floating masses of algae, from 20 to 30 yards from the margin and in from 3½ to 4½ feet of water. A few of these larvae were bred to maturity to confirm identifications.

The small lily-pond (Locality 3, Plate II, fig. 2) dried late in July 1919, and remained so until 4th January 1920. In May of 1919, when the water was two or three feet deep, a careful search was made for Tabanid larvae amongst the reeds and water-lilies, but none were found.

From 10th June 1919 onwards, the banks of this and adjoining ponds were examined from time to time as they dried, but in none of them were the larvae or pupae of *T. aprepes* found, although other species were taken.

From January 9th to April 16th 1920, when the ponds and swamps contained water, egg-masses and larvae were unsuccessfully sought for on many occasions. On the latter date a careful search was made of the vegetation growing near the banks and of the lily leaves in deeper water (4–5 feet) with the result that many larvae of *T. aprepes*, in all stages of development, were captured. On the same date a fly of this species was observed ovipositing (1.45 p.m.) on the underside of a seed capsule of a plant growing in eight inches of water and twelve inches from the bank. When about 30 eggs had been laid, a lamp chimney, closed at one end with mosquito netting, was slipped over fly and plant and tightly plugged with wadding. The stem was then cut off about an inch below the wadding plug, leaving the

fly and eggs practically undisturbed. In this position the chimney and its contents were returned to the water and overhanging plants. Several times during the next hour the fly appeared to be on the point of continuing oviposition, but each time returned to the netting without having extruded any eggs.

Between 21st and 25th April very heavy falls of rain and high winds caused an accumulation of drift (grass, aquatic plants, twigs, cow and horse dung, etc.) to be thrown up on the sloping banks of this and adjacent pools. When examined on 28th April, numerous half-grown to full-grown larvae of *T. aprepes*, *T. rufinotatus* and *T. nigritarsis* were found in the drift and on or under the soil beneath it ; while others were found buried in the grass-covered soil between the outer fringe of the drift and the foot of a stiff loamy bank three or four feet from it (Plate II, fig. 2). The latter were full-grown and were in some cases obviously at rest in the positions in which they intended to pass through the long dry period to follow ; in others they were still burrowing downward. Quite a number of those found in the drift, and especially in that part near the water's edge, were evidently feeding, as shown by the contents of the alimentary tract. Many of these larvae (*T. aprepes*) were captured and bred out in the laboratory in July and August.

While turning over the soil and drift on this date several recently discarded pupal cases were found and subsequently identified as those of *T. rufinotatus* and *T. nigritarsis*. These pupae were almost certainly the product of eggs laid more than a year earlier, since the unusual conditions of the 1919–20 season and the shortness of the possible breeding period (103 days) almost preclude the possibility of their being derived from eggs laid during the current year. No definite evidence has been obtained to determine the maximum period during which the larvae of these insects may remain in a dormant condition, but certain facts suggest that full-grown larvae may, after the usual long resting period and in the face of a drought, postpone their transformation into pupae for six months or more.

On the same date (28.iv.1920) and a few yards distant, full-grown larvae of *T. aprepes* were found making their way up a slope from the water's edge, through short wet grass and litter towards a bank (similar to that shown in Plate II, fig. 2) and about eight feet from the water's edge. Some were actually travelling when observed, others were sheltering in the grass or under debris.

These banks were examined four months later (30th August), when several *T. aprepes* (three pupae and five larvae) were found, and on the same afternoon an adult female was captured in the vicinity. The period (winter) intervening between these dates, 28th April–30th August, had been unusually mild and moist, doubtless favouring early development and rendering the emergence of the adults possible after even a light shower of rain. During the preceding year, owing to drought conditions, emergence of adult flies from this soil would have been a physical impossibility throughout the whole period April 1919 to January 1920.

Oviposition. In discussing breeding-places brief reference has been made to two flies which were observed in the act of ovipositing on 2nd and 16th April. As the process differed in several respects from that recorded for Indian and American species, it may be of interest to refer to it more fully here. At about 4.30 p.m. on 2nd April, whilst sitting by the water's edge (Locality 1), a fly was seen to alight on the underside of a twig about four feet above the surface of the pool (Plate I) and about three feet from my head. The twig lay at an angle of about 45° to the water, and the fly settled on it *head uppermost*. After lightly touching the surface of the twig many times with the tip of the abdomen, the first egg was extruded whilst only the extreme apex of the abdomen was flexed. Immediately the apex of the egg touched the twig it appeared to stick, and as it left the body it was forced out of the vertical position to an angle of about 20° ; the apex of the abdomen was again applied to the twig at the point of attachment and to one side of the egg just laid and a second

extruded in the same manner. Three eggs were then laid close to and in front of the first two, each one as it left the ovipositor being pressed firmly against those behind, until the latter lay almost parallel to the twig. In this way three or four gradually widening rows were laid, each slightly nearer vertical than the preceding one. Then a second and similar tier was commenced on top of those already laid, the first row of eggs of the second tier resting on the second or third row of the lower tier. Moving her body slightly forward, the fly extended the lower tier two or three rows before continuing the upper tier. In this way the operation was continued until the mass had covered the lower side of the twig for a length of 30 mm., when the fly moved forward a few millimetres and remained stationary until captured. The rate of oviposition was about three eggs a minute, and at no time was the apex of the abdomen brought *under the thorax*, as stated by writers dealing with extra-Australian species.

The Egg-mass. The size and shape of the egg-masses are very variable. As a rule they are about 20–33 mm. long by about 2 mm. wide when deposited on slender twigs or narrow blades of grass, or they may be more compact when laid on seed-heads or other objects offering a wider base for the mass. The mass is invariably as wide as the object upon which it rests and generally contains two layers of eggs. Some of the masses, however, contain three layers of eggs and are proportionately shorter and higher. Sometimes a second and even third mass is laid very near to or overlapping part of an earlier one, and small masses containing only a few score of eggs are found near masses of average size. The number of eggs per mass probably averages about 500, but much smaller and much larger masses, *i.e.*, 250–700, are found. At first the mass is creamy, but in the course of about 24 hours it changes to light slate-purple, and gradually darkens with the development of the larvae. There is a complete absence of the white chalky substance used by some species as an outer coating of the mass, and more often than not its general appearance is distinctly rough and lacking finish.

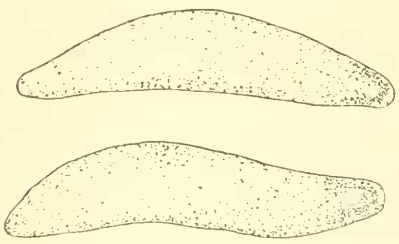

Fig. 1. *Tabanus aprepes*, Tayl., eggs.

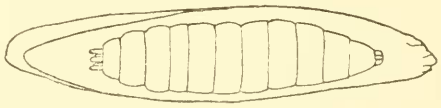

Fig. 2. *T. aprepes*, embryo 78 hours old.

The Egg. The eggs measure 1·60 mm. to 1·65 mm. in length, by 0·3 mm. in width, and are variable in shape according to their position in the mass, but always bluntly rounded at either end (fig. 1). The surface is smooth and glossy and, in recently laid eggs, pearly white. The colour changes rapidly; eggs that were laid at 1.50 p.m. on 16th April changed to grey by 5.15 p.m., to dark slate-purple by 9.30 a.m. on 18th, and hatched during the night of 22nd or early morning of 23rd. Another batch of eggs which was laid at 4.30 p.m. on 2nd April changed to dark slate-purple by 9.30 a.m. on 4th and hatched between 2 and 4 p.m. on 8th. The egg period therefore was from six and a quarter days to seven days in the one case and about six days in the other.

For at least 24 hours before the young larvae hatch they are distinctly visible through the clear, thin shell (fig. 2). During this period they are active, dark-banded little creatures, with the head always directed outwards from the point of attachment

of the egg-mass. When about to liberate themselves the blade-like process (egg-cutter) at the anterior end is pressed against the apex and drawn downwards along the side in two or three deliberate strokes, which cause a rent in the shell sufficiently large to permit the young larva to escape rapidly.

Larval Development. Generally speaking, there is only an interval of a few minutes between the appearance of the first and last larvae from a given batch of eggs. Sometimes, however, the interval is much longer, and this is especially the case with large masses, in which, owing to their form, many of the eggs are concealed beneath tiers of other eggs. One large mass from which all the larvae had apparently emerged before noon (13th January) produced 110 additional larvae before 9 a.m. on the following morning; another produced about 600 larvae during the morning and 30 more late in the afternoon.

In only one instance (5th April) was the dispersal of larvae observed under natural conditions. On this occasion several very small larvae were gathered on the surface of the pool (Plate I) in one dip of the scoop while searching for *Anopheles*, and upon examining some twigs overhead an egg-mass was found from which larvae were then dropping. The mass contained approximately 300 eggs, arranged in a single layer eight or ten abreast, of which number about one-third had already hatched and dropped into the water; the balance emerged during the succeeding five or six minutes. Upon reaching the water the young larvae were rather sluggish, but sufficiently active to disperse by slow lashing movements, some remaining on the surface film, others seeking the shelter of floating masses of algae. Some of these larvae were collected and removed to the laboratory for examination and observation.

In the laboratory the egg-masses were usually suspended over a shallow dish of clean water, into which the young larvae dropped as they freed themselves from the mass. For some hours they remained more or less quiescent on the surface, during which period the first moult was accomplished. This process commences before, or immediately after, the young larvae leave the egg, and is sufficiently advanced to be seen under a low power five minutes later. Apparently the first moult is always completed during the first six hours of larval life. As a number of larvae from one egg-mass have been reared through all their stages to the perfect fly, the development of these may be now recorded. While this batch was under observation a number of other batches were available for study, and they supplied much information and material for examination which could not have been obtained from the constantly decreasing ranks of the original batch.

The egg-mass from which the larvae were obtained was found partly evacuated on 13th January (Locality 1); 110 young larvae emerged from it on the afternoon and night of 13th–14th January and 105 of these comprised the original batch.

First Instar. An accurate description of the young larva soon after it emerges from the egg is somewhat difficult, owing to the fact that ecdysis has already commenced. When about five minutes old and after fixation in the usual way the young larva measures about 1·40 mm. long by 0·28 mm. wide at the sixth segment; the segments appear to be withdrawn into each other; the cuticle about to be cast off envelopes the body loosely, excepting at the head, where it is firmly attached. The surface is pale in colour and distinctly marked with longitudinal striae; several moderately long slender hairs are present about the middle of each segment; there are no short spine-like hairs fringing the anterior margin of the first three segments (thoracic), such as occur on the fourth segment and in increasing numbers on the fifth to the tenth segments. The anterior margin of the first two segments and the anterior and posterior margins of the following seven segments appear to be banded, but this appearance is due to characters on the cuticle beneath. The mandibles are withdrawn into the head, but in cleared specimens they are seen to be short, curved rods arising apparently in the anterior third of the first segment. The egg-breaker

is a black, chitinous, angular projection of the upper anterior margin of the labrum and is the most conspicuous feature of the first instar. Graber's organ is visible on the posterior portion of the tenth segment as a pair of dark, pyriform, closely approximated bodies.

Second Instar. Since most of the characters found in the larvae of the second instar are visible through the cuticle of, and appear to belong to, the first instar, the changes which follow the first ecdysis do not appear to be so great as they are in reality. Fixation in hot alcohol after the first ecdysis is completed and in all subsequent stages of larval development has the usual effect of extending the body to its fullest length ; thus, whereas the length of a larva of the first instar is about 1·40 mm., the length just after moulting is about 1·00 mm. greater. The measurements, descriptions and figures which follow are all from specimens fixed in hot 70 per cent. alcohol, and therefore fully extended. The characters of the larvae of the second instar are shown in fig. 3, which represents a larva between one and six hours old. Such larvae range

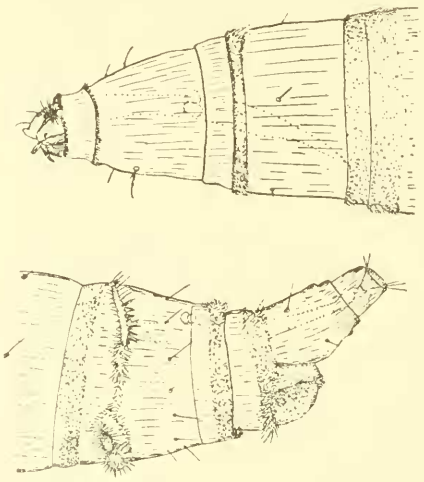

Fig. 3. *T. aprepes*, anterior end of larva 1–6 hours old (above) ; posterior end of same (below).

from 2·35 mm. to 2·63 mm. in length, by 0·375 mm. to 0·425 mm. in width at the widest part ; the segments bear distinct longitudinal striae ; the anterior border of each segment, excepting the first three (thoracic), is fringed with numerous small bristle-like hairs and dense short brown pile, which produce the banded effect (segments four to nine inclusive resemble the tenth segment shown in fig. 3). The first three (thoracic) segments are shown in fig. 3. The mouth-parts are prominent ; the first maxillae, palpi, and antennae are easily distinguished ; the anterior projection of the labrum is rounded and no longer black and chitinous ; four malpighian tubes are distinguishable ; Graber's organ still contains one pair of bodies, which are now seen to be enclosed in a pyriform sac, the rounded end of which is foremost ; the apical third of the syphon tube bears two groups of three long slender hairs, which usually appear to arise at the extremity owing to invagination of the apex and withdrawal of the stigmal plate.

During the 16 or 17 hours following the first ecdysis there is little apparent change in the young larva other than a slight increase in size and, generally, the addition of another pair of bodies in Graber's organ. A long series of larvae of this age measured from 2·35 mm. to 2·82 mm. in length, by 0·35 mm. to 0·425 mm. at the widest part.

For about three days following their emergence the young larvae do not feed, but remain on the surface film. After this period, however, they commence to attack each other, even in the presence of an abundant supply of small shells and other animal life introduced upon aquatic plants.

When twelve to fourteen days old the majority of the larvae measured from 6 mm. to 7 mm. in length, by 0·7 mm. to 0·85 mm. in width ; the groups of hairs on the syphon tube increased to four or five, and Graber's organ contained either two or three pairs of bodies, each pair diminishing in size from the anterior end. A few of the larvae had developed very slowly during these twelve days and now measured only 4·5 mm. in length. In two larvae (7 mm. and 8·5 mm. in length respectively) a second pair of mandibles could be distinguished in the anterior third of the first segment, and faint traces of the dark bands characteristic of older larvae of this species could be detected near the junction of the segments and near the anal protuberance. The second ecdysis apparently takes place when the larva is between 7 mm. and 9 mm. in length. Unfortunately the number of larvae in this batch became so reduced, largely owing to cannibal practices, that specimens could not be secured as frequently as desired to determine this point, but a " wild " larva captured on 2nd March appeared to represent an early stage of the third instar and to connect the last-described individuals with older and more advanced ones of the same batch. This larva measured 9 mm. in length by 1·5 mm. at the widest part ; the junctions of the segments were banded and blotched with dark brown, and the dorsal tubercles and the pseudopods bore short bristle-like hairs, as in older larvae.

On 2nd March, or when 49 days old, two larvae of the original batch measured 15 mm. and 16 mm. in length respectively. Whether the subsequent changes in the larvae follow ecdyses, or whether they are developed gradually during the third instar, has not yet been satisfactorily determined. On 16th April, or when 94 days old, two other larvae of this batch were destroyed by their fellows. The former now measured 21·5 and 24 mm. long by 3 and 4 mm. wide respectively. The brown bands and blotches are now very distinct and of the same pattern as in adult larvae ; the striae are well marked on all segments, but are absent on the brown areas ; the mandibles are black ; the bunches of stout curved spines above the insertion of the antennae are pale ferruginous, very prominent, and overhang what appear to be moderately large facetted eyes situated behind them ; in the smaller of the two larvae there are five pair of bodies in Graber's organ, in the larger six pairs ; the stigmal plate is now visible at the apex of the syphon tube. About the anterior third of the first segment (prothoracic) there are several long branched hairs, on other segments they are simple or absent ; the pseudopods are prominent ; there are no hairs on the anterior margin of the thoracic segments, these being confined to the dorsal ridges and pseudopods of the abdominal segments, where they are inconspicuous. The dark bands and blotches are formed entirely of very short and dense pile, as in the younger larvae ; the pseudopods were very prominent in the larger of the two larvae.

On the same date (16th April) the contents of the breeding-tray were collected, with the object of separating the remaining larvae of *T. aprepes* and several larvae of *T. nigritarsis* which had been placed in the tray recently. The former now numbered only five, two of which measured about 28 mm. long and three about 33 mm. long. One of the latter was retained for examination and is described below, the others were put separately into five-inch flower-pots half full of moist, clean granite sand, upon which lily leaves and shells were placed every three or four days. The larva referred to above was 94 days old at the time of its death, and measured 33 mm. in length and 5 mm. in width. In size and coloration, as well as in external form, it so closely resembles the mature larva which has undergone a long resting period that a description of it will suffice for both. There are six prominent pseudopods to each segment from the fourth to the tenth inclusive, arranged on the anterior margin, three on each side of the median line ; each pseudopod is armed with a number of short bristle-like hairs ; on the dorsal surface of the same segments there are two transverse

tubercles situated on the anterior margin on either side of the median line, which appear to be of the same nature as the pseudopods and similarly armed. The dorsal surface is blotched and banded boldly with dark brown (fig. 5), the pattern of which is very characteristic and constant. The ventral surface of segments four to nine inclusive are creamy white; from the dark anterior margin of the first segment

Fig. 4. *T. aprepes*, adult larva, lateral view.

Fig. 5. *T. aprepes*, adult larva, dorsal view.

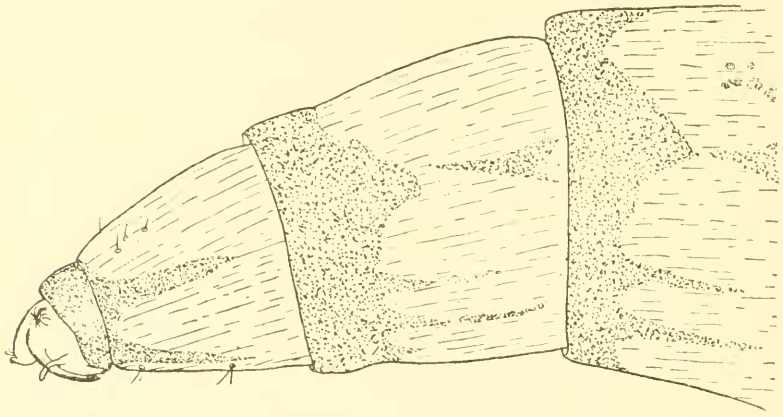

Fig. 6. *T. aprepes*, adult larva, anterior end.

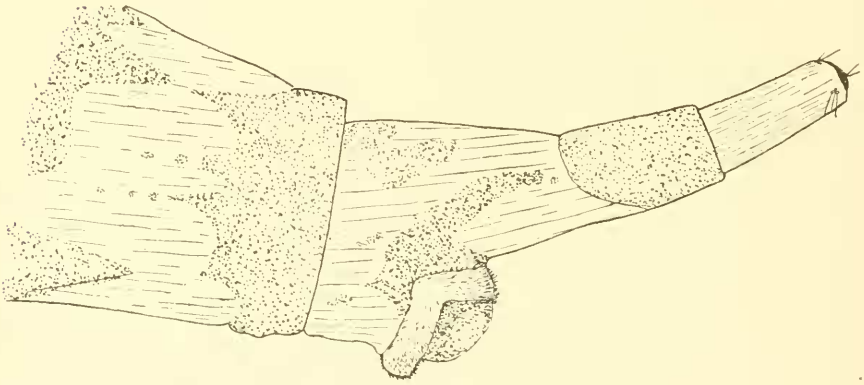

Fig. 7. *T. aprepes*, adult larva, posterior end.

(prothoracic) there extend posteriorly five dark, lanceolate marks, one on either side of the dorsal and ventral surfaces, and one in the median line of the ventral surface. The second and third segments are banded anteriorly (fig. 6) and the tenth posteriorly (fig. 7) with brown.

As the larvae reached maturity and ceased to feed (about the third week in April) they were placed together again in a large receptacle containing moist sand, in which they remained for about two months. At first they were very active, coming to the surface at night and returning to the sand during the day, but never attacking each other. On 3rd June they were all in a torpid state and contracted to about 18 mm. in length, but when placed in water they regained their normal appearance and activity.

On 25th June one of the larvae, now 164 days old, pupated in a vertical position four inches below the surface and after a pupal period of 11 days emerged as a perfect fly (female). Another larva pupated about a week later and was preserved as a specimen ; the third pupated on the 7th July and produced a male fly on 21st July, or 190 days after hatching ; the fourth remained in the larval stage until 8th September (239 days), when it was destroyed for examination.

Larval Habits under Natural Conditions. Under natural conditions the larvae are to be found commonly on or near the surface of clear and moderately deep pools, amongst submerged herbage near the banks, resting upon the lower surface of lily leaves, upon the submerged stems and leaves of all kinds of aquatic plants and in floating masses of algae. Clear and moderately deep water appears to be essential. The food of the young larvae is not known, but it is believed to be the small molluscs, which were fed successfully to larvae reared in captivity. Several kinds of molluscs are very plentiful in most of the breeding-places, and these certainly form an important part of the diet of older larvae, which have frequently been found feeding on them.

In the rock-hole (Locality 1) this food is absent, but there is a plentiful supply of other kinds. Cannibalism is common amongst " wild " larvae, and is practised by individuals in all stages of development. To give some idea of the voracy of these insects, it may be mentioned that on one occasion 12 large larvae were placed in a pickle-jar of water and algae for transportation to the laboratory—a journey of three miles—and upon arrival there only two remained alive, one of which destroyed the other before arrangements could be made for their separate accommodation. On another occasion over 50 nearly full-grown larvae were placed in a large porcelain dish with sand, water and fresh molluscs. Within four days many of the latter and 40 of the larvae were destroyed.

With the aid of a small stout wire net attached to the end of a long bamboo rod the plant growth can be disturbed sufficiently to dislodge the larvae, which, even if carried down by the currents thus created, soon appear near the surface and are easily captured in the net. In some cases a stout wire hook at the other end of the rod was found useful for dragging masses of vegetation towards the bank for closer inspection. Wading was resorted to in many cases, but the results were usually unsatisfactory on account of the restricted range of vision.

The larvae appear to live entirely in water until they have reached maturity, when they migrate from the water to high ground close by, as described elsewhere in this paper, and penetrate into the soil or clay to a depth of from 7–15 cm., where they remain in the larval stage, generally with head uppermost, for several months.

The Pupa. During the first few hours following metamorphosis the entire pupa is buckthorn-brown,* but the eyes soon deepen to mummy-brown, and then to blackish brown, while the thorax becomes argus-brown. The average size is about 21 mm. in length by 4 mm. in width at the thorax, the 1st and 6th segments slightly narrower than the 2nd to 5th inclusive.

On the dorsal surface of the first abdominal segment there are two stout hairs on either side of the median line and three on each pleura, two of which arise close together near the wing-sheaths. Segments 2 to 7, inclusive of both surfaces, bear an

* Ridgway's colour nomenclature.

uninterrupted fringe of long and short bristles arranged roughly in two rows, the shorter bristles nearer the base ; on each segment from the 2nd to 5th these bristles increase in length ; on the 5th, 6th and 7th they are equally long or, rarely, the long bristles may be absent from the middle of the seventh tergite and sternite and the shorter ones may be branched.

The six projecting spurs at the apex of the abdomen are arranged three on each lobe of a prominent bilobed tubercle divided vertically by a deep cleft, which is wider in the males ; the upper and middle pair are equally long and stout, the lower are smaller ; on either side of the dorsal surface midway between the base of the tubercle and the apex of the 7th segment there is a group of four or five stout spines of unequal length. The length and stoutness of these bristles vary greatly in individuals of either sex.

The anal tubercle is very large and deeply furrowed in the male and is bordered anteriorly by an unbroken fringe of about 18 to 22 stout bristles of variable lengths. In the female the fringe is broadly interrupted in the middle, and consists of from 6–9 bristles on either side (fig. 8).

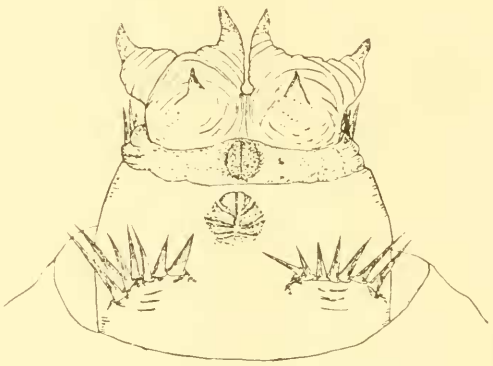

Fig. 8. *T. aprepes*, ventral surface of last segment of female pupa.

Duration of the Pupal Stage. The duration of the pupal period during the months June–September varied from 8 to 20 days, the average being 12 days in the case of 10 individuals whose periods were accurately observed.

The factors which determine early or late emergence of laboratory specimens are not known, and no explanation can be offered at present of the fact that whilst certain pupae of a batch pass through a very short pupal stage—*e.g.*, eight days—others of the same batch and subjected to the same treatment may remain in the stage for periods up to 20 days.

Emergence of the Fly. The emergence of laboratory-bred flies has been observed on several occasions—always between 10 a.m. and 4.30 p.m.—and in each the procedure was similar. The pupa, with its body vertical, works its way to the surface, from which it protrudes the thorax and first two or three abdominal segments. In this position it remains motionless for from one to two hours ; then, with very little apparent effort, the thorax is burst on the dorsal surface to the posterior margin of the mesothorax, and also along the lower margin of the eyes, leaving a flap-like piece bearing the anterior group of tubercles more or less loosely attached ventrally. The fly frees itself in a minute or two, leaving the greater part of the pupal case as before. At emergence the wings are uniformly opaque, but in the course of an hour or two they become hyaline or suffused with brown, as the case may be.

The Adult. The adults of this species show considerable variation in regard to size and coloration and, as might be expected, in laboratory-bred specimens this is more

apparent than in those bred under natural conditions. In a recent paper* it has been stated that the wings show various gradations in colour from a total absence of infuscation to a very pronounced shading, especially at the veins. A long series of males and females bred out in this laboratory show these gradations to a marked degree, not only in flies reared from full-grown larvae captured in natural surroundings, but also in flies reared from the same batch of eggs. Variations in abdominal coloration of both sexes, and especially in the females, is even more pronounced. In some specimens there are evident spots at the apex of certain segments, in others the abdomen is of uniform dark brown or uniform ochraceous tawny. In three wild females captured in June in this district the colour of the abdomen is so light as to lead the writers of the above-mentioned paper to refer them with some doubt to this species. Recently, however, a similar form has been bred from a batch of eggs which also produced individuals showing all the variations of wing and abdominal coloration. It would appear that in this and other species too much attention has been paid in the past to slight or even marked differences of this kind. When these variations in colour are associated with abrasions of the abdomen and thorax, and especially of the front, the possibilities of error in diagnosis are greatly increased unless a fairly long series is available for comparison.

In life the lower third and the lateral and posterior margin of the eyes of the male are claret-brown with emerald-green iridescence ; the upper two-thirds are drab grey and composed of coarse facets. In the female the facets are small throughout and the colour uniform drab grey with brown iridescence.

Seasonal Occurrence. Throughout Australia, perhaps excepting the wet belts of the North Queensland coast, of which I have little knowledge, there is a marked seasonal occurrence of flies of this family, namely from about October to April. In the southern regions, where there are regular winter rains and low winter temperatures, the emergence of flies is probably regulated by temperature and not by rainfall ; but in the north, where the temperature is more or less equable and the rainfall is, excepting for moderate falls, confined to the summer months above mentioned, the condition of the soil, whether dry or wet, is most certainly the regulating factor. Thus almost invariably the march-fly season is either early or late, good or bad (from the collector's point of view) according to whether the summer rain is early or late and normally heavy, light or absent.

The chief natural breeding-places in this district, and in most others with which I am familiar, are in temporary accumulations of water, such as shallow swamps, which disappear completely in the winter or dry season and after the full-grown larvae have entered the soil in the vicinity of the water's edge, wherever that may be at the time of their reaching maturity. As the soil dries these larvae are practically immobilised, and remain so until it again becomes thoroughly moistened. It follows, then, that there can be no emergence of flies until after heavy rain has fallen.

The truth of these statements has been demonstrated on many occasions, and notably during the summer of 1919–20, when until 4th January the country was in the grip of a severe drought, and there was an almost complete absence of Tabanids in this district. Heavy rains for a short period in this month were followed by the appearance of a moderate infestation of flies. (It may be stated here that the previous season also was one of unusually low rainfall, and therefore an unfavourable one for fly breeding.) The January rainfall was not sufficiently heavy to raise the level of the swamps to normal, and another long spell of dry weather intervened before the banks in the vicinity of the normal high-water marks were thoroughly saturated. About the middle of April abundant rains filled the swamps, and there followed a marked increase in the number of flies in the district. Whether the flies were derived from eggs laid in January 1920 or during the preceding wet season could not be

* Ferguson & Hill, in the press (Proc. Linn. Soc. N.S. Wales).

determined, but the period required for the life-cycle, as ascertained later, suggests strongly that the latter was more probable. Further, there is no evidence to suggest that the Tabanids in this or other districts known to me produce two generations in one season. Obviously these remarks do not apply to localities in which there is permanent surface water, such as Locality No. 1.

In some localities a few individuals of certain species, particularly *T. rufinotatus*, are to be found throughout the dry season (June to August), but their occurrence can be accounted for by the presence of permanent water (such as Locality No. 1), or at any rate marshland, in the vicinity.

During June of this year numerous young larvae were found in pools which dried a few weeks later. The question naturally arises whether these larvae perish or whether they are able to burrow into the mud to lie dormant through the remainder of the dry season and until conditions again become favourable for their development. Attempts to determine these questions have been unsuccessful, but it may be mentioned that one larva from a late batch of eggs was, when about 9 mm. long, accidentally isolated in the laboratory in a pot of dry sand and without food of any kind from about 6th June to 28th August. On the latter date it had the general appearance of adult larvae in the resting stage preceding pupation, and became active immediately it was placed in water containing suitable food and cover. Unfortunately neglect caused its death before any development could be detected. Hine, working in America, found that certain Tabanid larvae after a long resting period again fed before pupating, but nothing of the kind has been observed to take place in the case of any of the species studied here.

Rearing Larvae in Captivity. Various methods of rearing the young larvae were tried, but as none of them gave satisfactory results it is not intended to describe them in detail. In order to prevent cannibalism young larvae were isolated in small earthenware pots with a capacity of about 120 c.c., prepared in various ways, and supplied with various kinds of food. Apart from the difficulty of keeping the water in these vessels fresh, this method was found to be too cumbersome, and the larvae rarely survived for more than a week or so. Larger vessels, *i.e.*, five-inch flower-pots and small museum jars, were equally unsatisfactory. Kerosene tins cut lengthwise into two equal parts gave better results, and in them a few larvae were reared from the egg to maturity. These tins were prepared by placing a quantity of clean sand at one end and two or three inches of water at the other. Pieces of water-lily leaves, algae and swamp plants carrying small molluscs were placed in the water to afford shelter and food, and these were renewed as often as possible. The water was changed every four or five days by lifting one end of the tin and allowing it to filter through the sand. The tin was then partly filled and again emptied in this way, before being finally replenished with water and food-bearing vegetation. Each tin contained the progeny from one batch of eggs, *i.e.*, 300–600 larvae, of which never more than 1–2 per cent. reached the imago stage. When molluscs were not obtainable mosquito larvae and small earthworms were offered as substitutes, but worms were invariably refused by larvae in all stages of their development. Mosquito larvae were destroyed by the Tabanids when the former were stranded in algae or sand, but otherwise they appeared to have been able to avoid capture. At all times Tabanids of this species appear to feed upon their fellows in preference to molluscs or any other animals, and for this reason it was found best to transfer the survivors, when of nearly full size, to separate pots or dishes, where they completed the development in moist sand, upon which molluscs and portions of lily leaves were placed. The best results were obtained from a batch of 105 larvae which were reared in a concrete trough, measuring 16 inches wide by 20 inches long by 6 inches deep, prepared similarly to the tins just referred to. As the larvae approached maturity the water was gradually reduced until it was confined to a small area at one end of the trough. In this molluscs were placed every week or so, until

it was found that none were being devoured, when the water was drawn off and the trough half filled with clean sand, which was kept moist. From time to time the sand was turned over to watch the progress of development, but beyond this the larva received no attention for intervals of several weeks. Some of the larvae pupated and produced flies in this trough, but most of them were transferred to small pots of clean moist sand, where they completed their development. In future it is intended to use these large troughs or galvanized iron trays instead of the smaller vessels.

Tabanus rufinotatus, Big.

T. rufinotatus, Bigot, Mem. Soc. Zool. France, v, 1892, p. 673.

T. lineatus, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 65.

T. elestëem, Summers, Ann. Mag. Nat. Hist. (8) x, 1892, p. 224.

T. designatus, Ricardo, Res. Expéd. Sci. Néerlandaise Nouv. Guinée, ix, pt. 3, 1913, p. 390.

Distribution. This is a widely distributed species, having been recorded from South Australia, New South Wales, Queensland and the Northern Territory, and also from Dutch New Guinea. The South Australian specimens in the British Museum collection are most probably from Port Darwin (Northern Territory) or its vicinity, which prior to 1911 formed part of the state of South Australia.

Breeding-places. On 25th March 1919, an egg-mass was taken from the lower surface of a *Juncea* leaf growing three feet from the bank of a shallow water-hole (near Locality 3) in twelve inches of water. At the time the pool contained a maximum depth of three feet of water and was much frequented by cattle and horses which grazed in the district. As the season advanced the water dried back rapidly and finally disappeared before the end of May. During the period intervening between 25th March and 28th May 1919 the vegetation near the water and the muddy banks and bottom were searched for egg-masses and larvae respectively, but without success. During the same period and up to the present date (September 1920) many other possible breeding-places have been repeatedly examined, but so far only a few adult larvae have been secured.

The Egg-mass. The egg-mass referred to above, from which the larvae described in the following notes were derived, measured 5·5 mm. in length by 4·25 mm. in width at the base and 3·5 mm. in height. The eggs, which numbered about 500, were arranged very compactly in three tiers and were coated, either separately or collectively, with a white secretion. After the larvae hatched, the mass retained its form so perfectly that, viewed from any direction but from above, it appeared to be still composed of viable eggs.

Larval Development. The larvae hatched almost simultaneously at noon on 30th March and moulted between that hour and 9 a.m. on the following day. Specimens were not secured prior to ecdysis, so that the first instar cannot be described here.

The Second Instar (figs. 9, 10). When 24 hours old the larvae of the second instar measured from 2·5 mm. to 2·6 mm. in length by about 0·25 mm. in width at the widest part. Up to this age they were of uniform size, but at the end of the second day variations became apparent, some measuring 3 mm., while others had increased to 3·5 mm. The cuticle is creamy white and bears minute longitudinal striae ; the tufts at the base of the antennae are short and many of the component hairs are forked ; the prothoracic segment is short, and the hairs which fringe its anterior margin and the anterior margin of the next segment are difficult to discern. The dorsal tubercles and pseudopods are armed with moderately large hairs, and each segment bears several isolated long, slender, pale hairs.

The young larvae remained in a small dish of water for three days without food, when they were placed in a large concrete trough containing sand at one end and

water at the other. In this they were offered small molluscs, young mosquito larvae and small aquatic animals that adhered to the water-lily leaves used to provide cover. From time to time dead larvae were found which appeared to have been destroyed by their fellows, but the remainder seemed to thrive. On 10th June, or when 77 days old, one of the larvae measured 15 mm. in length. Unfortunately this specimen was lost before a detailed description was obtained. On 3rd July the sand was allowed to dry off gradually, and from this date onwards small earthworms only were offered as food. On 8th October the sand was washed over, but no larvae were found. The vessel and its contents were left undisturbed until 27th October, when the now dry sand was sifted, yielding three larvae measuring from 22 mm. to 23 mm. in length by about 2·5 mm. in width. In such larvae the cuticle is glossy and devoid of the striae observed in larvae of the second instar, there is no trace of banding, and the hairs on the dorsal tubercles and pseudopods are colourless.

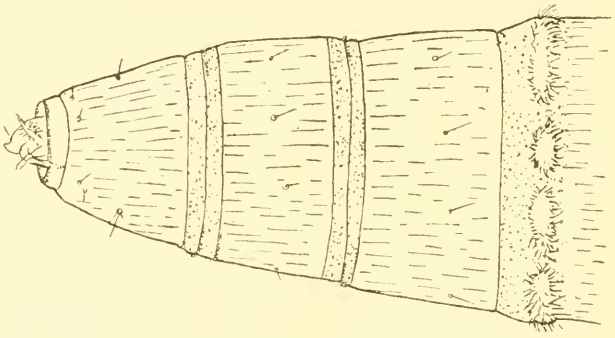

Fig. 9. *Tabanus rufinotatus*, Big., anterior end of larva 24–48 hours old.

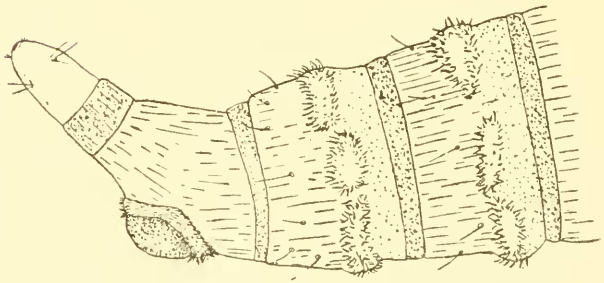

Fig. 10. *T. rufinotatus*, posterior end of larva 24–48 hours old.

The two remaining larvae were now placed in a large shallow dish, containing sand at one end and water at the other, in which they were fed on earthworms and mosquito larvae until 8th November, when they were placed separately in five-inch flower-pots standing in a dish of water and containing three inches of clean sand. On 8th December both larvae were evidently fully grown. One of these was secured for examination and is described below, the other was returned to its pot, to which had been added a few small earthworms and a little earth. A week later it was found dead and damaged beyond recognition by scores of nematode worms. The loss of the sole surviving larva rendered the identification of the species with which I had been dealing for over nine months impossible for the time being, but the larvae secured on 27th October

and 8th December provided the material from which a determination was subsequently made in comparison with a series of " wild " larvae, some of which were subsequently bred out.

The Adult Larva (figs. 11, 12). The full-grown larvae measure from 26 to 29 mm. in length by about 4 mm. in width, and are creamy white in colour, with the faintest indication of darker bands ; the cuticle is glabrous and without striae ; the tufts at the base of the antennae are composed of short stout hairs ; there are no hairs on the anterior margin of the thoracic segments, and those of the dorsal tubercles and pseudopods are very short, slender and dark in colour.

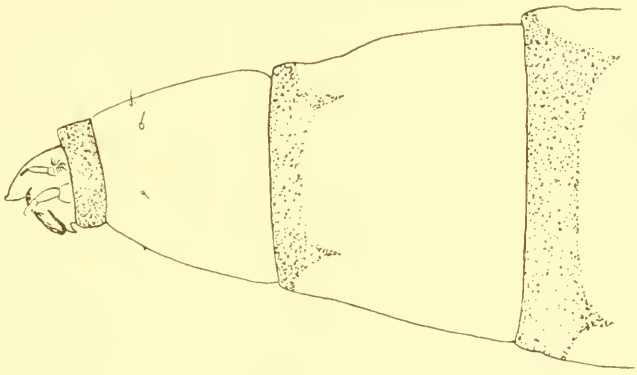

Fig. 11. *T. rufinotatus*, anterior end of adult larva.

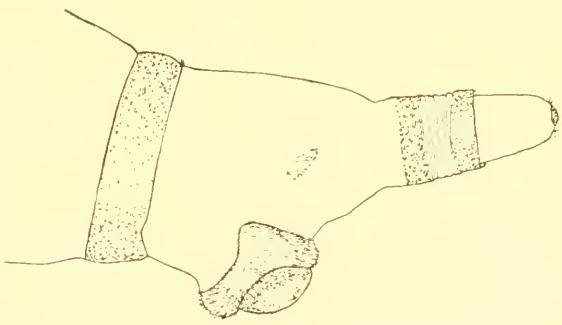

Fig. 12. *T. rufinotatus*, posterior end of adult larva.

From this record it will be seen that under laboratory conditions the larval stage was not less than eight and a half months.

Development of Larvae under Natural Conditions. Larvae were taken on 28th April 1920 in association with the larvae of *T. aprepes* and *T. nigritarsis* (see notes on *T. aprepes*), and again in a similar bank on 15th June in association with the larvae of *Silvius notatus*. After securing specimens for examination, the remainder were placed in small earthenware vessels containing sand, which were thereafter kept moist. The flies emerged as follows :—one female on 23rd May (after a pupal period of nine days), one male on 2nd June, and one female on 21st July.

The Pupa. The average length of the pupa is about 15 mm. and the width at the thorax about 4 mm. The eyes are blackish ; the vertex (in the female) and thorax Dresden brown, the latter with faint traces of stripes ; abdomen ochraceous tawny, with Dresden brown stripes corresponding to the black stripes on the abdomen of the

imago. The first abdominal segment bears two isolated hairs on either side of the median line and one on each pleura behind the spiracle; the second to seventh tergites and pleurites each have a double row of bristles, those of the anterior row being much shorter than those of the posterior. On the ventral surface, segments 2, 3 and 4 each bear an irregular single row of bristles of varying length; on the 5th to 7th segments the bristles are arranged in two rows; the terminal segment bears the usual number of large spurs (six); anterior to the anal tubercle there is, in the male, a fringe of about twenty long straight or curved bristles, which in the female is interrupted in the middle and is composed of five to eight stout and generally straight bristles (fig. 13). In the male the anal tubercle is large and deeply ribbed, in the female it is small but prominent. On either side of the dorsal surface, midway between the base of the upper pair of spurs and the posterior margin of the 7th segment, there is a group of six or eight stout bristles of irregular size and shape, which in the female is reduced to two or three much smaller bristles; in addition, in the male, there is on either side a group of two or three very short bristles midway between the above and the posterior extremity of the anterior fringe.

Fig. 13. *T. rufinotatus*, ventral surface of last segment of female pupa.

The Adult. In life the eyes of the male have the upper part grey, with deep brown iridescence, and the lower part, lateral and hind margins maroon, with an emerald-green band in line with the insertion of the antennae. The facets of the lower part are larger than those of the upper. In the female the eyes are maroon to dark maroon-purple, with two broad green bands in line with the callus and subcallus respectively.

Seasonal Occurrence. These flies were very scarce indeed during the period February 1919 to September 1920. Females were seen or captured in the field in the months of January, February, April, June, September and December, generally while buzzing about one's head or resting upon one's hat. Horses (locally and in the Northern Territory) appear to be more troubled than cattle, the former usually being bitten about the nose, ears, rump and coronet.

Tabanus nigritarsis, Tayl.

T. nigritarsis, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 67.

Distribution. This species has been recorded previously from North Queensland (Houghton River) and the Northern Territory (Darwin, Stapleton, etc.).

Breeding-places and Habits. Between the 19th May and 10th June 1919 five apparently full-grown larvae were gathered from the submerged stems or leaves of

various plants growing in a few feet of water at the margin of a small swamp (Locality No. 3, Plate II) and removed to a concrete trough containing a pile of sand at one end and water at the other. In this vessel they were fed upon molluscs until 3rd July, after which date food was refused by them. The water was now drained off and the sand allowed to dry gradually until only the bottom two inches remained moist, in which condition it was kept for about four months. On 19th August one of the larvae was found in a vertical position about three inches below the surface of the sand. The body was then much contracted, but when placed on the surface the insect became more or less active and extended its length to about 25 mm. This specimen was allowed to bury itself again, and remained undisturbed in the sand until 8th October, when it and two other larvae were found in the above condition. One of these was preserved in the usual way and is described in these notes ; the others were placed separately in five-inch flower-pots full of sand and imbedded in the sand contained in the larger vessel, where the two remaining larvae of the original batch of five were presumed to be resting. The two larvae in pots remained very active, but refused to eat either molluscs or earthworms, although they came to the surface almost nightly until 18th November. On 26th November one of these larvae was found undergoing metamorphosis, the other following on the morning of 1st December (11 a.m.), the former producing a female fly on 12th December and the latter a male on 17th December (between 9 and 10 a.m.).

On 27th November the sand in the large trough was sifted and another larva secured, which pupated on 12th December (5 p.m.) and produced a female fly on 28th December. The fifth larva was not recovered and was, therefore, presumed to have been destroyed by its fellows during the early days of their captivity. From the foregoing it will be seen that the pupal period in the laboratory was 16–17 days. Throughout the greater part of their lives in captivity these larvae and pupae showed much restlessness, and in the latter days of their pupal existence frequently wriggled to the surface or projected the posterior end above it, proceedings which would have been impossible under natural conditions owing to the hardness of the soil in which they would have been embedded.

As previously noted (under *T. aprepes*) a few larvae of this species were found in the resting stage in a clayey bank in this locality on 25th April 1920, associated with *T. aprepes* and *T. rufinotatus*. On 15th June following five additional specimens of *T. nigritarsis* were taken under similar conditions in the same locality. At the time of writing (30th September 1920) the majority of these are still in the larval stage in moist sand, others which at the time of capture were embedded in balls or tubes of plastic clay and placed on the laboratory shelves to dry were equally healthy and active when released on 30th September.

The Larva. The adult larva measures about 35 mm. in length by 5·5 mm. in width and is cream-coloured, faintly blotched and banded with yellow ochre (figs. 14–17). The pseudopods are arranged two on either side of the median line on the ventral surface and one on each pleura, these and the dorsal tubercles being only slightly elevated. The surface of the cuticle is dull and distinctly marked with longitudinal striae, except where banded or blotched.

The Pupa. The pupa measures about 23 mm. in length by 4 mm. across the thorax and 5 mm. across the abdomen at the widest part. The eyes are blackish brown, the thorax slightly lighter and the abdomen argus-brown. The first abdominal segment bears two slender hairs on either side of the median line, one on each pleuron behind the spiracle, and two closely approximated hairs on the ventral surface near the margin of the wing-sheaths. On the dorsal surface of the 2nd segment there is a double row of bristles, the anterior row short, stout and of irregular size, the posterior much longer ; the 3rd segment is similar to the 2nd ; on the 4th, 5th and 6th the bristles increase in size gradually from the 4th posteriorly ; on the 7th there are fewer long bristles in the posterior row, their place being occupied by others of intermediate size.

On the pleurae the armature is similar to that of the dorsum, except on the 7th segment, which resembles the ventral surface. On the ventral surface the 1st, 2nd and 3rd segments bear a single row of mixed short and long bristles increasing in length from the 2nd; the 5th and 6th segments resemble the corresponding segments of the

Fig. 14. *Tabanus nigritarsis*, Tayl., adult larva, lateral view.

Fig. 15. *T. nigritarsis*, adult larva, dorsal view.

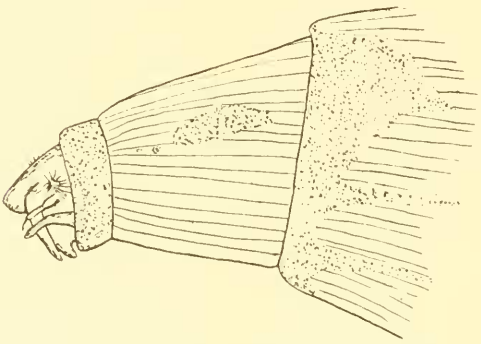

Fig. 16. *T. nigritarsis*, anterior end of adult larva.

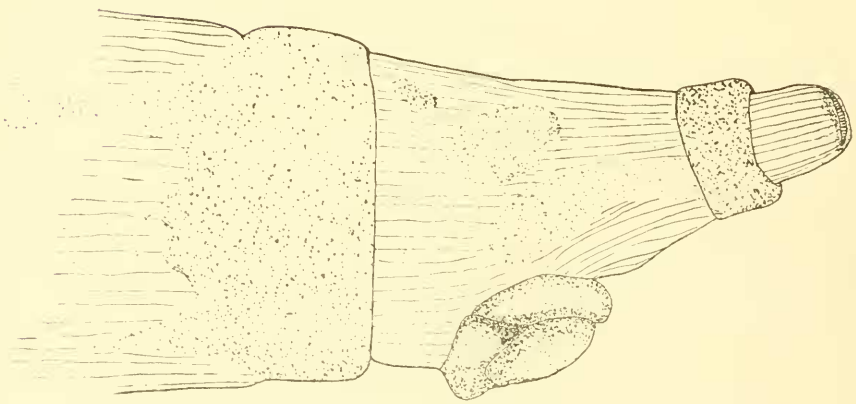

Fig. 17. *T. nigritarsis*, posterior end of adult larva.

dorsum, the 7th is similar, but has some short bristles in the posterior row. The integument of both surfaces bears transverse striae on the anterior two-thirds of each segment, which are generally absent or replaced by punctures on the posterior third. The armature of the terminal segment is variable. In most specimens there

is on the dorso-lateral margins, and midway between the base of the second pair of projecting spurs and the posterior margin of the 7th abdominal segment, a well-developed group of from five to seven very irregular bristles arising from a raised base. In some specimens these bristles are reduced to three or four in number, and in one they are absent on one side and on the other represented by two rudimentary bristles. In the male the anal opening is bordered anteriorly by a semicircle of stout and very irregular bristles, some of which are expanded and branched at the base, others short and almost rudimentary, or all may be long and moderately slender. Posteriorly the opening is bordered by a raised and deeply furrowed prominence. In the female (fig. 18) the fringe of bristles in front of the anal opening is broadly interrupted in the middle, each group being composed of from five to eight bristles of variable size.

The Adult. In life the eyes of the male are dull yellow-green and coarsely facetted above the point of junction of the eyes on the front; below this and on the sides and posterior margin the facets are smaller and bronze-coloured, with gold and green iridescence. In the females the eyes are uniformly dull yellow-green.

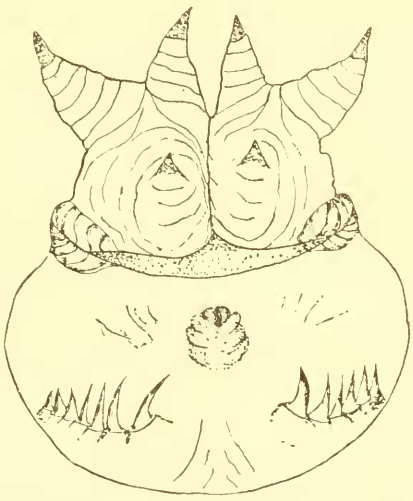

Fig. 18. *T. nigritarsis*, ventral surface of last segment of female pupa.

Seasonal Occurrence. Apart from the three flies reared in the laboratory only two individuals (females) have come under my notice during the period 25th February 1919 to 30th September 1920. Both were captured whilst attacking horses during the last week in February of this year. In the Northern Territory (1912–1917) this species was regarded as the most numerous and most troublesome to stock during the months of December-February. The egg-masses found there were small and compact and were generally placed on the underside of pandanus leaves overhanging water.

Silvius notatus, Ric.

S. notatus, Ricardo, Ann, Mag. Nat. Hist. (8) xvi, 1915, p. 264.

S. psarophanes, Taylor, Proc. Linn. Soc. N.S.W. xlii, 1917, p. 520.

S. fuliginosus, Taylor, *op. cit.* xl, 1915, p. 810.

Distribution. This Tabanid is a widely distributed species, having been recorded from S.W. Australia, Victoria, New South Wales, South Queensland, North Queensland and the Northern Territory (*S. fuliginosus*, Taylor).

Although so widely distributed, it would appear to be a rare species in this district, where, apart from those referred to above, only one specimen (the type of *S. psarophanes*) has been recorded hitherto. Nothing is known of its early stages and the feeding habits of the larvae and adults.

Breeding-places and Habits. On 22nd August 1919, while breaking down and sifting the low banks of a small lily-covered pool (Locality No. 3) about 24 Tabanid larvae were found in nearly dry, stiff, loamy soil at depths below the surface varying from 10 to 30 cm. In most cases the larvae lay in a vertical position with the head uppermost, others lay horizontally, and a few vertically with the head downward. At the time the bank was distant 12 feet from the water's edge and six feet from the mud which intervened between it and more or less dry soil. All the larvae were in the lower part of the bank in soil which had been above water-level since about 12th May, and although a search was made in the mud and adjacent dry soil no larvae were found there. The undamaged larvae, 16 in number, were removed to the laboratory and placed in two five-inch flower-pots containing moist soil, in which they remained undisturbed until 8th October. From the 22nd August until 22nd September they were very restless and wandered over the surface of the soil at night. These movements ceased on the latter date, and on the 8th October about one inch of the surface soil in one pot was temporarily removed, exposing the head and thorax of three pupae. The colour of the eyes and wing-sheaths indicated that they were then from about three to five days old. The oldest was preserved as a specimen, and the others were placed separately in pots of earth, from which they emerged as flies (♂ and ♀) on 13th October after a pupal period of about eight days. On the same date two males emerged from the second pot. Other flies emerged as follows:—1 ♂ on 25th October, 1 ♂ on 3rd November, 1 ♀ on 8th November, 1 ♂ on 24th November, 1 ♀ on 26th November, 1 ♀ 30th November, 1 ♂ 2nd December (pupal period 14 days), 1 ♀ 12th December.

On 15th June 1920 two resting larvae were taken from the bank shown in Plate II, fig. 2, and were transferred to small pots of sand, where they still remain in the larval stage (30th September).

The Larva. The adult larva measures about 33 mm. long by 4 mm. wide and is of a creamy white colour with narrow orange citrine bands at the anterior end of each of the first ten segments. On the first three segments the banding is obscure and on the 11th it is confined to a collar-like expansion of the posterior margin. Each abdominal segment, excepting the last, bears a slightly elevated transverse ridge or tubercle about half as wide as the segment, as well as a pseudopod on either lateral margin and a pair of pseudopods on the ventral surface. Macroscopically the dorsal and ventral surfaces are similar in appearance. The integument is glabrous and bears very distinct longitudinal striae. The first and last segments, and especially the spiracle (figs. 19, 20), differ greatly from those of any species of the genus *Tabanus* known to me. Grabner's organ has not been made out.

The Pupa. The pupa measures from 18–20 mm. in length, 3–3·5 mm. in width across the thorax, and 3·5–4·0 mm. across the widest part of the abdomen. The colour varies, according to age, from chestnut-brown to mars brown, head and apices of wing-sheaths blackish brown, lower surface and sides of first abdominal segment ochraceous tawny. In the male the head is as wide as the thorax, in the female slightly less. The abdomen is nearly cylindrical in both sexes. The thoracic spiracles are large and overlap the posterior margin of the head. The first abdominal segment bears two slender hairs on the tergite and one on each pleurite near the wing-sheath. The second tergite bears an interrupted single row of very short stout and irregular bristles and three or four long bristles, generally towards the sides. The third, fourth

and fifth tergites are similar, except that the bristles are stouter and there are about eight long bristles on each. On the sixth and seventh tergites the bristles are fewer and stouter than on the preceding ones. On the pleura they are arranged roughly in two rows, those in front being much shorter and fewer than those behind. Sternites 2–7 are armed similarly to their corresponding pleurites. On the anterior half of each tergite there are five or six small dark-coloured depressions, the foremost being nearest the pleura and the hindmost nearest the median line. Behind the anterior margin of each segment and parallel with it there is another row of three or four similar depressions on either side of the median line. The anterior two-thirds of each tergite, pleurite and sternite are distinctly marked with transverse striae ; posterior to the bristles these striae are less distinct or absent and the whole surface is punctate.

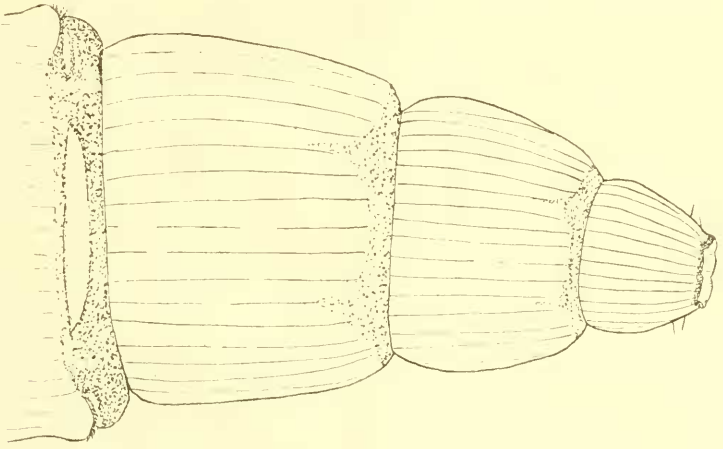

Fig. 19. *Silvius notatus*, Ric., anterior end of adult larva.

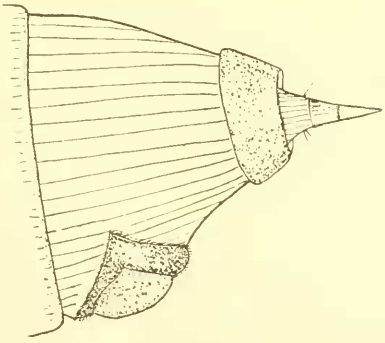

Fig. 20. *Silvius notatus*, posterior end of adult larva.

The terminal segment is deeply rugose, the two upper projecting spurs or bristles are parallel along their inner margins in the female and divergent in the male ; the middle pair is much larger than the upper and lower and projects laterally. The anal tubercle of the male is very large and deeply furrowed ; in front it is bounded by a continuous fringe of bristles, four or five comparatively small ones in the middle and a group of four or five very stout ones on each side, similar to but larger than

those of the female (fig. 21); the latter group of bristles is continued, with a slight interruption, around the sides of the segment to a point in line with the base of the lower pair of spurs. The size and number of these bristles are variable in both sexes, but are generally largest and fewest in the males.

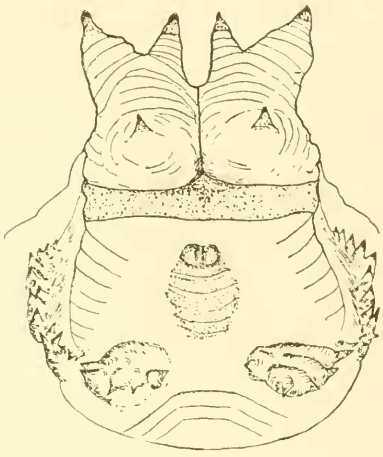

Fig. 21. *Silvius notatus*, ventral surface of last segment of female pupa.

The Adult. In life the eyes of the female are of uniform light seal-brown and the facets of equal size throughout. In the male the greater part of the surface of the eye is of the same colour, but at the lower third it is crossed by a sinuous, iridescent blue-green and copper band, which extends to near the lateral margins and is continued (in light seal-brown) around the posterior margin to the vertex. The facets forming this band are very small, while the remainder are large.